Appendix 2

Effect of the Sun-Earth distance change on solar irradiance

Let us calculate the effect of change of S–E distance d on the TSI S at the Earth using the inverse square law:

$$S = I_0/d^2 \qquad (1)$$

where I_0 is the solar radiation at the Sun defined by solar activity.

Then for the TSI restored at 1700 (Lean et al. 1995) as shown in Figure 10.2 (middle plot) is S_0 = 1366 W/m^2, which gives the average intensity I_0 of solar radiation at the Sun expressed as $I_0 = S_0 \times d_0^2$. This gives the starting average intensity I_0 of solar radiation

$$I_0 = 1366 \times [d_0]^2, \text{(W)} \qquad (2)$$

where d_0 is the S-E distance at the time of observations in 1700 when this magnitude of TSI is derived. Then the solar irradiance S_1 at any other time t_1 can be defined by the inverse squared law as follows:

$$S_1 = S_0\, d_0^2 / d_1^2 \qquad (3)$$

For simplicity's sake, let us assume this power I_0 does not change at the Sun. The TSI is normalised by the magnitude in 1700 (Lean et al, 1995). The daily TSI variations are presented for every month in millennium M1 (600-1600) (Figure A2.1) and M2 (1700-2600) (Figure A2.2).

It is evident that TSI in M2 is consistently higher in the first 6 months than in M1 because the S-E distances at these months of M2 are smaller (see Appendix 1). In addition, it is noticeable in Figure A2.3 the extra-input of solar radiation caused by SIM in January-July in M2 compared to M1 following the Sun-Earth distances variations (see Appendix 1).

In order to evaluate if the two processes: extra TSI input in January-July and reduced TSI input in August-December are compensated, the annual variations of TSI for three years in each millennium are plotted in Figure A2.3 for millennium M1 (left) and millennium M2 (right). The plots demonstrate the shift of the TSI input in M2 to mid-July leading to stronger heating in the summer/winter in Northern/Southern hemisphere and stronger cooling in mid-January during the winter/summer in Northern/Southern hemisphere.

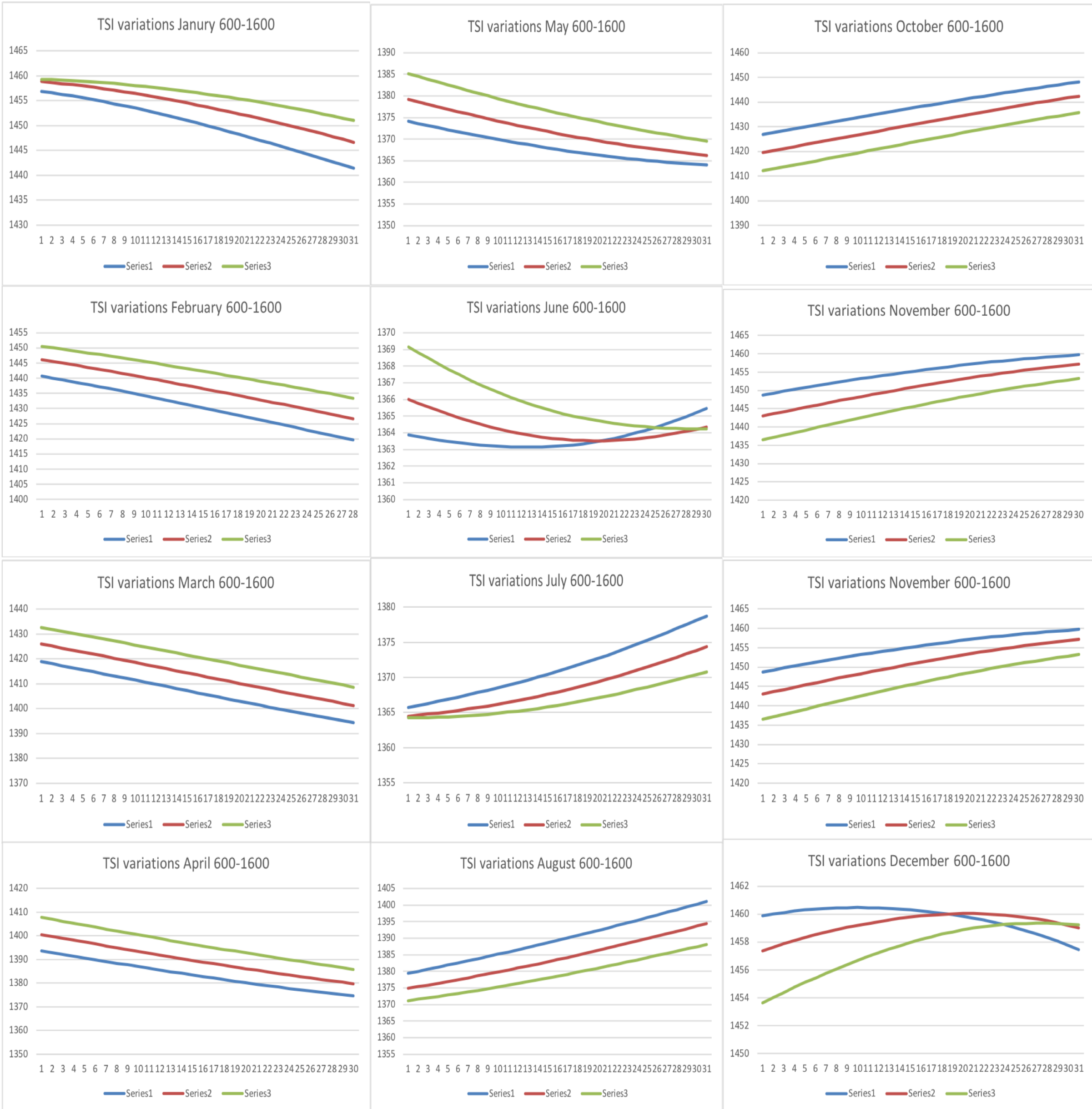


Figure A2.1. Total solar irradiance variations (Y-axis, W/m^2) with the S-E distances presented in Appendix 1 (Figure A1.1) for M1: years of 600, 1100, 1600. The X axis shows days of a month.

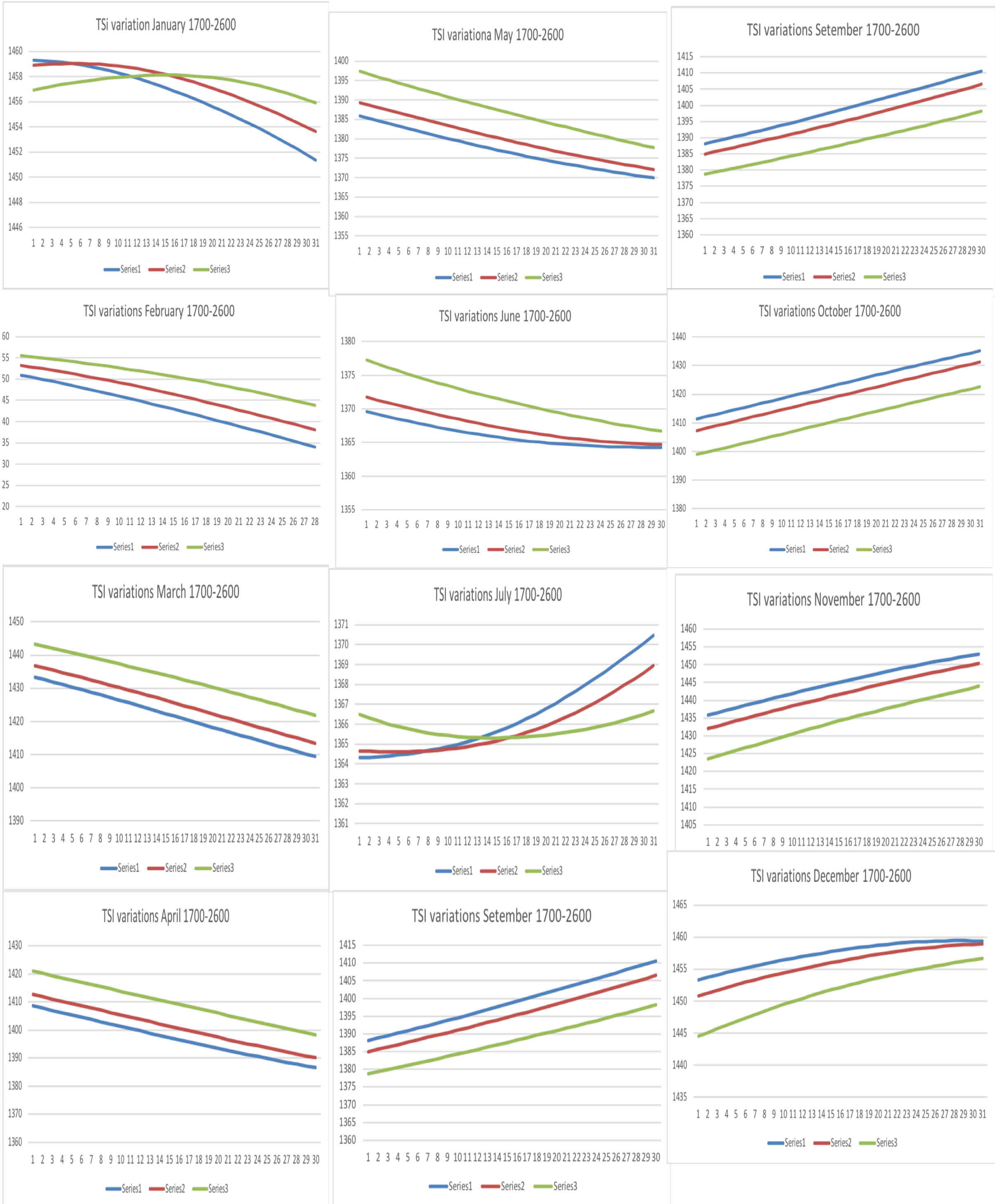


Figure A2.2. Total solar irradiance variations (Y-axis, W/m^2) with the S-E distances presented in Appendix 1 (Figure A1.1) for M2: years of 1700, 2020, 2600. The X axis shows days of a month.

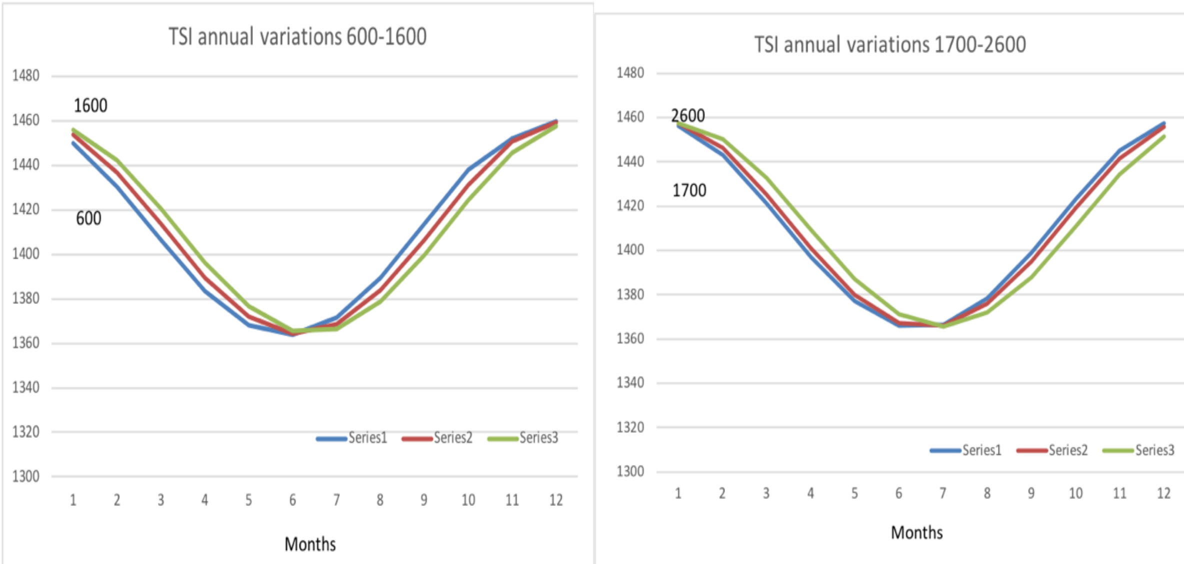


Figure A2.3. Annual variations of the total solar irradiance (Y-axis, W/m^2) in millennia M1: 600 (blue), 1100 (red), 1600 (green) and M2: 1700 (blue), 2020 (red), 2600 (green). X axis shows months of a year.

See explanations of the plots presented in Figures A2.1-A2.3 in the chapter, section 6.